Energy, Mines and Resources Canada
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1976 Assessment of CANADA'S COAL RESOURCES AND RESERVES

Report EP 77-5

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Preface

Previous studies on Canada's coal resources have reported resources as the total quantities of all types and categories of coal. These studies at their time of publication were useful; however, in retrospect, they did not provide the complete picture of Canada's coal resources. In this report coal resources are considered in terms of both the quantity and quality of the coal in the ground. Also introduced in this report is the concept that coal resources should be reported in individual categories according to two considerations: (1) the level of assurance of their existence; and (2) the feasibility of their exploitation. Thus, a grand total of Canada's measured, indicated and inferred coal resources is not reported.

For 1976 the quantity of resources of immediate interest is estimated at 31.9 billion tons of Measured Resources, 14.6 billion tons of Indicated Resources and 181.5 billion tons of Inferred Resources. The quality aspects of these resources are also discussed in this report.

For the first time the Department is publishing an estimate of Canada's coal reserves, defined as that portion of coal resources that has been reasonably well delineated and can be produced with current technology and delivered at competitive market prices. Current reserves of recoverable coal are estimated at 717 million tons of coking coal and 5.2 billion tons of thermal coal. Because of exclusion of reserves from several companies and utilities, the estimate of current reserves of recoverable coal is considered to be conservative.

The Department's intentions for implementing a National Coal Inventory Program and a National Coal Data System in conjunction with the provinces and industry are outlined in the report. The National Coal Inventory Program ultimately will result in the determination and compilation of data and information on the quantity, quality, mineability and economics of Canadian coal and interpret the information into a meaningful estimate of coal reserves in terms of cost and availability.

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Introduction

Historical background

The first assessment of the coal resources in Canada was prepared by Dowling (1913) for the 12th International Geological Congress held in Canada in 1913. This first estimate included resources in thin coal seams down to great depths. More than three decades later MacKay (1947) published a comprehensive reappraisal of the first estimate of Canada's coal resources. By using seam thicknesses and depths of cover which varied from coalfield to coalfield and by excluding seams less than 3 feet thick, MacKay reduced the original figure by a factor of ten. A later revision of MacKay's estimate, made in 1960, incorporating the new information becoming available resulted in an estimate of 60 billion tons of probable resources and 33 billion tons of possible resources. In 1973, the Department of Energy, Mines and Resources, based primarily on a study of western Canadian coal resources by Latour and Chrismas (1970) reported 9.8 billion tons of measured resources, 50.2 billion tons of indicated resources and 58.6 billion tons of inferred resources in the publication "An Energy Policy for Canada".

Department's current objectives

The 1973 oil embargo and subsequent quadrupling of oil prices has given a sense of renewed urgency to the evaluation of our other indigenous energy resources. Canada has the potential of regaining self-reliance in alternative domestic energy sources such as coal.

The Government's strategy aims at replacing imported oil with domestic energy sources, with coal assuming an ever-increasing role in the policy of self-reliance over the next quarter century. Within the past five years Canada's coal industry has experienced an unprecedented expansion in supply concomitant with an expanding market for coking coals for export and for lower rank coals for mine-mouth thermal electric power generation. In response to these expanding opportunities, the Department in collaboration with the provinces and with industry is increasing its research and development in coal as well as reappraising Canada's coal resources and reserves. This reappraisal will provide a firm data base for long-term decisions within the constraints of environmental factors, technological limitations and cost benefits.

Projections of possible coal demand point to very rapid rates of increase in Canadian coal production between now and the turn of the century, with almost a tripling of current demand levels expected over the next decade. The bulk of these production increases will be to meet future domestic demand for low rank coals for electric power generation. The role of the Canadian government in coal is largely one of coordination within the complexities of a system of confederation in which the ownership and management of resources reside for the most part within the jurisdiction of individual provincial governments. In certain instances the needs and objectives of provinces are not necessarily the same as those of Canada and studies on a national basis have to take this into account in their correlation with various provincial programs.

In the recent report "An Energy Strategy for Canada" (1975) the Government of Canada through the Department of Energy, Mines and Resources proposed to take a number of initiatives where possible in concert with the provinces to reduce the dependence on imported oil. The National Coal Inventory Program is one important step. This program is intended to generate a compendium of information derived from private and public sector programs with due regard for the limitations imposed by their differing goals.

In September 1976 the Honourable Alastair Gillespie, Minister of Energy, Mines and Resources, announced at the Annual Ministers of Mines Conference in St. John's, Newfoundland that discussions had been held with the coal producing provinces related to the federal objective of providing increased resource information. The Minister announced that an understanding had been reached with provincial governments to cooperate on a number of issues, particularly for the coal inventory program. Previously, agreements were reached for joint federal-provincial coal inventory programs in Saskatchewan, Nova Scotia and New Brunswick funded on the federal side by the Department of Energy, Mines and Resources and the Department of Regional Economic Expansion. The Saskatchewan lignite resources evaluation program is nearly complete whereas the Nova Scotia and New Brunswick programs are still underway.

Coal Assessment Group

In keeping with the need for an improved understanding of Canada's coal reserves and resources, the Department of Energy, Mines and Resources has established a Coal Assessment Group based on the coal expertise within the Department. This Group has coordinated and prepared for publication this report on Canada's Coal Resources and Reserves.

This Group is modelled on the previously established Uranium Resource Appraisal Group which produces the annual assessment of Canada's Uranium Supply and Demand. The Coal Assessment Group will develop programs for gathering the necessary data for reporting annually on coal supply and demand along with pertinent data on quantity, quality and mineability as well as economic information. In addition the Group will develop and coordinate a National Coal Inventory Program.

Historically, resource assessments in Canada have concentrated on measuring the quantity of coal in place and the assessment of quality has been neglected. Thus, the quality of Canada's coal resources other than their rank is known in only the most general terms. One important objective of the Coal Assessment Group is to rectify this situation. Realization of this objective involves assimilation of all existing data as well as actual field programs designed to produce new data and to collect information on the physical and chemical properties of individual coals.

National Coal Inventory Program

The National Coal Inventory Program is designed to determine and compile data and information on the quantity, quality, mineability and economics of Canadian coal as well as to interpret the information to provide estimates of coal reserves in terms of cost and availability. It is intended the Department of Energy, Mines and Resources act with the provinces in gathering information on a provincial basis. A proposed structure in which a National Coal Inventory Program will be carried out is illustrated in Figure 1. A subsidiary objective of this program will be to standardize coal resources and reserves terminology in Canada in cooperation with the provinces.

National Coal Data System

To achieve a national coal inventory it is recognized that a National Coal Data System will have to be implemented to compile information on quantity, quality, mineability and economics. The main elements of a National Coal Data System are:

Recent drilling about 50 miles northeast of the Minto Coalfield has delineated two small coalfields, each containing one thin seam and having some 15 million tons of measured resources between them.

A joint federal-provincial drilling program is in progress to explore for additional coalfields in the province.

Ontario (Figure 5)

A thin, Lower Cretaceous sequence called the Mattagami Formation underlies the southern part of the Moose River Basin which lies adjacent to the Canadian Shield of northern Ontario. The sequence consists of sandstones, clays and lignitic coal and the area underlain by it is known as the Onakawana Coalfield. Some 240 million tons of measured resources of high moisture coal have been delineated over an area of about 15 square miles.

Manitoba (Figure 5)

Thin, lignitic coal seams which are an extension of the deposits in southern Saskatchewan occur in southwestern Manitoba. The few outcrops scattered over the deposit reveal that the seams are too thin to be included within the limits set for resources in this report.

Saskatchewan (Figure 5)

Seams of Paleocene lignitic coal of mineable thickness are confined mainly to four discrete major basins: Estevan, Willowbunch, Wood Mountain and Cypress. These basins were delineated and evaluated by drilling carried out under a joint federal-provincial coal evaluation program as well as from data provided from drilling by companies. Computer methods of determining resource estimates, developed during the program, have enabled researchers to calculate the resources readily within each 50-foot increment of depth from the surface. This refinement in the data breakdown is not shown in Table II.

Lignitic coal also occurs in the Wapawekka area near Lac La Ronge in central Saskatchewan. The limited data available indicate that the coal is rather high in ash and that the seams rarely attain the minimum mineable thickness of 5 feet.

Alberta (Figure 6)

Table II indicates that Alberta is estimated to contain some 19.6 billion tons of measured coal resources and 120 billion tons of inferred coal resources. These estimates have been prepared by the Alberta Energy Resources Conservation Board (1974) and are classified by them as being "ultimate remaining in-place reserves". The terminology and classification criteria used by the Board differ considerably from those used by the Department of Energy, Mines and Resources. It would appear, however, that the total of measured, indicated and inferred resources of the Department corresponds to the "ultimate remaining in-place reserves" of the Board. The classification criteria and methodologies used by the Board tend to produce higher estimates than would be obtained in EMR although the extent of the difference is difficult to determine.

Following in part the practice of MacKay (1947, p. 39), the province for convenience is divided into three sectors, each containing deposits of similar age and characteristics. These are the Inner and the Outer Foothills Belts and the Plains Region.

The Inner Foothills Belt extends along the eastern flank of the Rocky Mountains, and contains medium and low volatile bituminous coal deposits mainly of Upper Jurassic and Lower Cretaceous age. The sulphur content is invariably low and much of the coal is of excellent coking quality. The seams are commonly friable, steeply inclined, highly sheared and faulted. In areas of intense folding the seams are often thickened. Such areas of thick coal seams are of particular interest to mining companies as possible sites for mining operations.

The Outer Foothills Belt parallels the eastern margin of the Interior Plains and contains mainly high volatile bituminous coals of Upper Cretaceous and Lower Tertiary ages. They appear to be developed best in the area between the North Saskatchewan and Athabasca Rivers. Like their counterparts in the Inner Foothills Belt, these coal beds have been sheared, faulted and folded. At the outcrop or near the surface anomalous thickening can provide favourable sites for surface mining.

The Plains Region is characterized by generally flat-lying or gently inclined seams of Upper Cretaceous age and mainly of subbituminous rank. Outcrops are uncommon and information about the deposits is largely obtained through drilling. The proximity to surface of some of the seams allows for their recovery by surface mining methods — the means by which almost all the coal in the region is produced.

British Columbia (Figure 6)

Coal deposits are widely scattered through British Columbia. For purposes of discussion and tabulation of resources, the province has been divided into three regions: southeastern, northeastern and other.

The coal deposits of southeastern British Columbia are commonly referred to as the Crowsnest Coalfield. This coalfield, mined since 1897, has been extensively explored and is the only area in the province where coal is now being mined. The deposits are Upper Jurassic in age and are an extension of the Inner Foothills Belt as described for southern Alberta with the notable difference that they contain considerably more seams that are of greater thickness. The resources of this area consist of 6.9 billion tons measured, 10.4 billion tons indicated and 40.0 billion tons inferred.

The Lower Cretaceous coal deposits of northeastern British Columbia occur in the northern extension of the Inner Foothills Belt. The area has undergone much exploration in the past several years. Current resource estimates are larger than past estimates and there are indications that further increases will occur as exploration continues.

Several small basins of Tertiary coal occur in the south-central part of the province, including Tulameen, Princeton, Merritt and Hat Creek Basins. The Hat Creek Basin is by far the most important because of the exceptionally thick, near surface, lignitic seams (160, 225 and 500 feet) which give rise to very large tonnages in a small area. Jura-Cretaceous deposits occur in the Telkwa and Bowron River areas of central British Columbia. Mining experience at Telkwa over the past 30 years has shown the deposits to be intensely folded and faulted and to be intruded by igneous rocks. Small scale exploration in the Bowron deposit has indicated that the seams are of limited extent and irregular in thickness.

The Jura-Cretaceous deposits of the Groundhog Coalfield in northern British Columbia are little known and understood. However, because of their apparent size and thickness, there appears to be a relatively high potential for low volatile bituminous and anthracitic coals of high ash content.

Three small areas underlain by Upper Cretaceous coal deposits occur on the east coast of Vancouver Island. The Nanaimo Coalfield produced coal for many years but is now considered to be completely mined out. The more accessible parts of the Comox Coalfield have been mined out and only the deeper less accessible coal remains. What little is

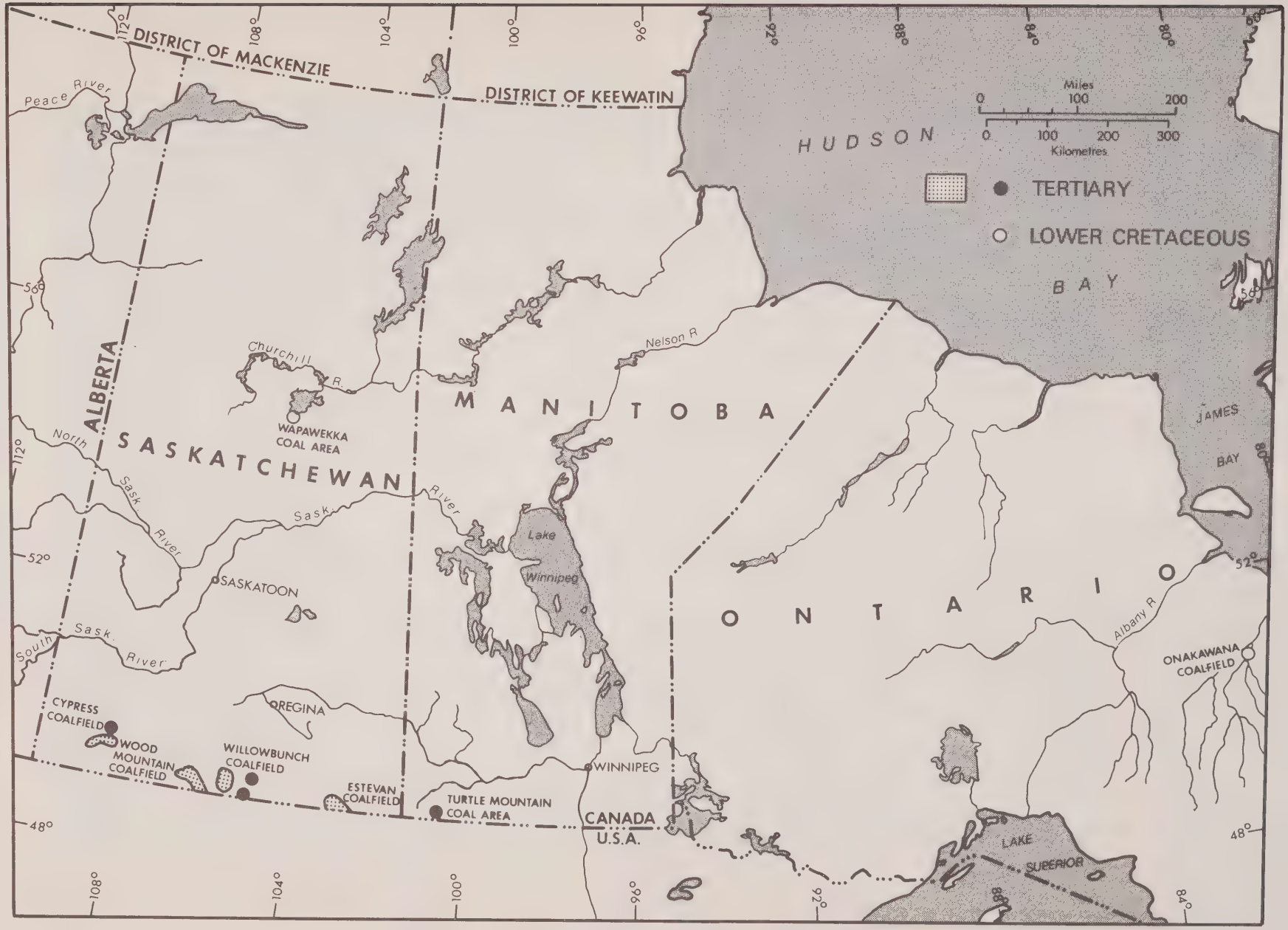


Figure 5. Coal deposits of Ontario, Manitoba and Saskatchewan, by age.

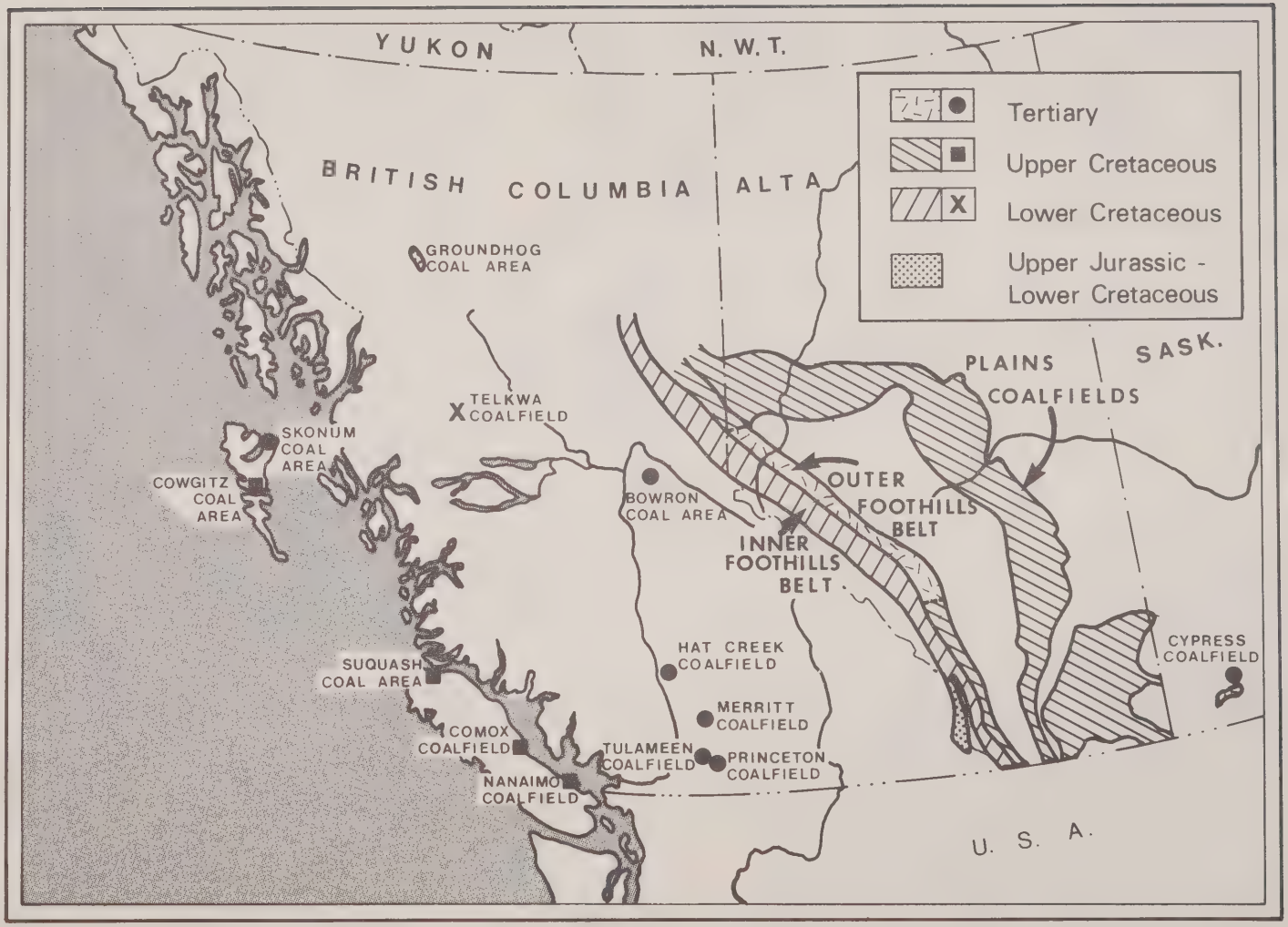


Figure 6. Coal deposits of Alberta and British Columbia, by age.

known about the remaining area of Suquash as well as the Cowgitz and Skonun coal areas of the Queen Charlotte Islands indicates structural and stratigraphic problems. These low quality coals, locally intruded by igneous rocks, do not appear attractive for exploitation.

Estimates of the coal resources of this province are based on information obtained from the British Columbia Department of Mines and Petroleum Resources and that obtained by the Department of Energy, Mines and Resources from other sources.

Northern Canada (north of 60° latitude) (Figure 3)

Although it has been known for almost two hundred years that coal occurs in northern Canada, with few exceptions production has been limited to small scale operations for local consumption at such places as Pond Inlet, Aklavik and Paulatuk in the Northwest Territories and Carmacks, Whitehorse, Burwash Landing and Dawson City in Yukon Territory. The only mines with a recorded production are the Five Fingers, Tantalus and Tantalus Butte mines, all near Carmacks, Yukon Territory. Tantalus Butte mine is the only producing mine in all of northern Canada.

Significant occurrences of coal are widespread in the Canadian north although the information is almost entirely confined to reports of seams exposed in outcrop. Seams up to 30 feet thick have been noted, but further details of these occurrences have not yet been reported. As yet not even speculative resources have been estimated for this large region, but such information as exists suggests a very high likelihood of large coal resources.

Qualitative assessment of Canada's coal resources

Coal as it occurs in the deposits underground, and as measured for resource and reserve assessments is made up of consolidated organic residues from decomposed vegetation plus mineral constituents intermixed and inter-bedded during the period of deposition. The American Society for Testing and Materials (ASTM) defines coal as "readily combustible rock containing more than 50 weight per cent and more than 70 volume per cent of carbonaceous material, including inherent moisture formed from compaction and induration of variously altered plant remains similar to those in peat. Differences in the kinds of plant materials (type), in degree of metamorphism (rank), and in the range of impurity are characteristics of the varieties of coal".

It is readily apparent that pure coal is a complex material of variable quality. Gross coal, the material as assessed in deposits, is even more complex and variable because of the inclusion of mineral matter in varying quantity and kind.

The classification of pure coal by rank is only a beginning in defining the quality of the gross coal which includes varying amounts of mineral matter in a deposit. According to the ASTM system of classification of coals, outlined below and summarized in Table III, ranks are determined mainly by measuring heat value and volatile matter by prescribed methods. The ranks are defined as functions of the calorific value (expressed in Btu per pound) and fixed carbon* calculated to the mineral-matter-free basis. The occurrences of the various ranks of coal in Canada are shown in Figure 7.

A secondary parameter involved in rank determination is derived from examination of the residue incident to the volatile matter determination. An agglomerate residue with specified strength or a residue showing swelling or cell structure is considered agglomerating from the standpoint of coal classification. Agglomerating coals therefore are those that on heating in the absence of air soften and become plastic. Agglomeration is a necessary fundamental property for coke manufacture and influences the design of combustion equipment. In general bituminous coals are agglomerating, whereas anthracitic, subbituminous and lignitic coals are non-agglomerating.

Anthracitic class

- coal having 14 per cent or less volatile matter on the dry, mineral-material-free basis. These coals are non-agglomerating. In general they are used for heating and as a source of carbon. Although occurrences of anthracite coals have been noted in Canada, those anthracitic coals that are mined have volatile matter greater than 8 per cent and are ranked as semi-anthracite.

Bituminous class

Because this class covers a wide range of heating values and volatile matter contents and includes both agglomerating and non-agglomerating coals with different potential usage, a further division is made into five groups, the groups are identified as follows:

- *low volatile bituminous* (*lvb*) — coal having between 14 and 22 per cent volatile matter on the dry, mineral-matter-free basis; commonly agglomerating.
- *medium volatile bituminous* (*mvb*) — coal having between 22 and 31 per cent volatile matter on the dry, mineral-matter-free basis; commonly agglomerating.
- *high volatile A bituminous* (*hvAb*) — coal having more than 31 per cent volatile matter on the dry, mineral-matter-free basis and a moist mineral-matter-free heating value of more than 14,000 Btu per pound; commonly agglomerating.
- *high volatile B bituminous* (*hvBb*) — coal having a moist mineral-matter-free heating value of between 13,000 and 14,000 Btu per pound; commonly agglomerating.
- *high volatile C bituminous* (*hvCb*) — coal having a moist, mineral-matter-free heating value between 11,500 and 13,000 Btu per pound, and commonly agglomerating; and coal having a moist, mineral-matter-free heating value of between 10,500 and 11,500 Btu per pound and agglomerating.

Bituminous coals are usually agglomerating and therefore have potential for the manufacture of coke for the metallurgical industry. In general, although not restricted to such usage, medium volatile and low volatile bituminous coals are prepared for the metallurgical industry and other ranks of bituminous coals are prepared for thermal use. High volatile A bituminous coals are frequently blended with low and medium volatile coals for the metallurgical industry.

Subbituminous class

- Coal having a moist, mineral-matter-free heating value of between 8,300 and 11,500 Btu per pound; non-agglomerating. Coals of this class are further grouped as A, B and C in decreasing order of heating value. Coals of this class are recognized as thermal coals.

Lignitic class

- Coal having a moist, mineral-matter-free heating value of between 6,300 and 8,300 Btu per pound, non-agglomerating.
  Coals of this type are recognized as thermal coals.

* Fixed carbon is a calculated value. It is the resultant of the summation of percentage moisture, ash and volatile matter subtracted from 100.

TABLE III

Summarized Classification of Coal by Rank

Fixed carbon * (per cent)	Class	Group (rank)	Calorific value ** (Btu per lb.)
98 —	Anthracitic (1)	Meta — Anthracite	
		Anthracite	
92 —		Semianthracite	
86 —	Bituminous (2)	Low volatile bituminous	
78 —		Medium volatile bituminous	
69 —		High volatile A bituminous	14,000
		High volatile B bituminous	13,000
		High volatile C bituminous	11,500
	Subbituminous (4)	Subbituminous A (3)	10,500
		Subbituminous B	9,500
		Subbituminous C	8,300
	Lignitic (4)	Lignite A	6,300
		Lignite B	

* Dry, mineral-matter-free basis.
** Moist, mineral-matter free basis.

(1) Non-agglomerating; if agglomerating classified as low volatile bituminous.
(2) Commonly agglomerating.
(3) If agglomerating classified as high volatile C bituminous.
(4) Non-agglomerating.

The above definitions compare coal quality parameters of mineral-matter-free coal either on a dry basis (fixed carbon) or on the basis of the natural inherent moisture (calorific value).

Canada has the following kinds of coal listed in accordance with their classification by rank (see Figure 7):

Nova Scotia	— Medium and high volatile bituminous
New Brunswick	— High volatile bituminous
Ontario	— Lignite
Manitoba	— Lignite
Saskatchewan	— Lignite
Alberta	— Semianthracite, low, medium and high volatile bituminous, subbituminous, lignite
British Columbia	— Low, medium and high volatile bituminous, subbituminous, lignite.
Yukon Territory	— Low, medium and high volatile bituminous and lignite.

In addition, occurrence of anthracitic coals in the Kathlyn Lake and Groundhog areas in British Columbia and in the Colchester area in Nova Scotia have been recorded.

Table IV presents typical analyses of Canadian raw coals. These analyses are of the kind required for resource and reserve assessments and should not be confused with the analyses for prepared and marketed coals which are published annually. (See Tibbetts, 1975 and Tibbetts and Montgomery, 1975.)

On examination of the coal quality data, it becomes apparent that the measurement of resources in billions of tons without consideration of coal quality can lead to erroneous conclusions concerning potential energy supplies. For example, a resource of 5 billion tons of Nova Scotia coal could have the equivalent energy supply impact of 10 billion tons of Saskatchewan lignite.

Bituminous coal suitable for coke making is produced in Nova Scotia, Alberta, and British Columbia. Various coals that are suitable for the thermal coal market are produced in Nova Scotia, New Brunswick, Saskatchewan, Alberta, British Columbia, and the Yukon Territory.

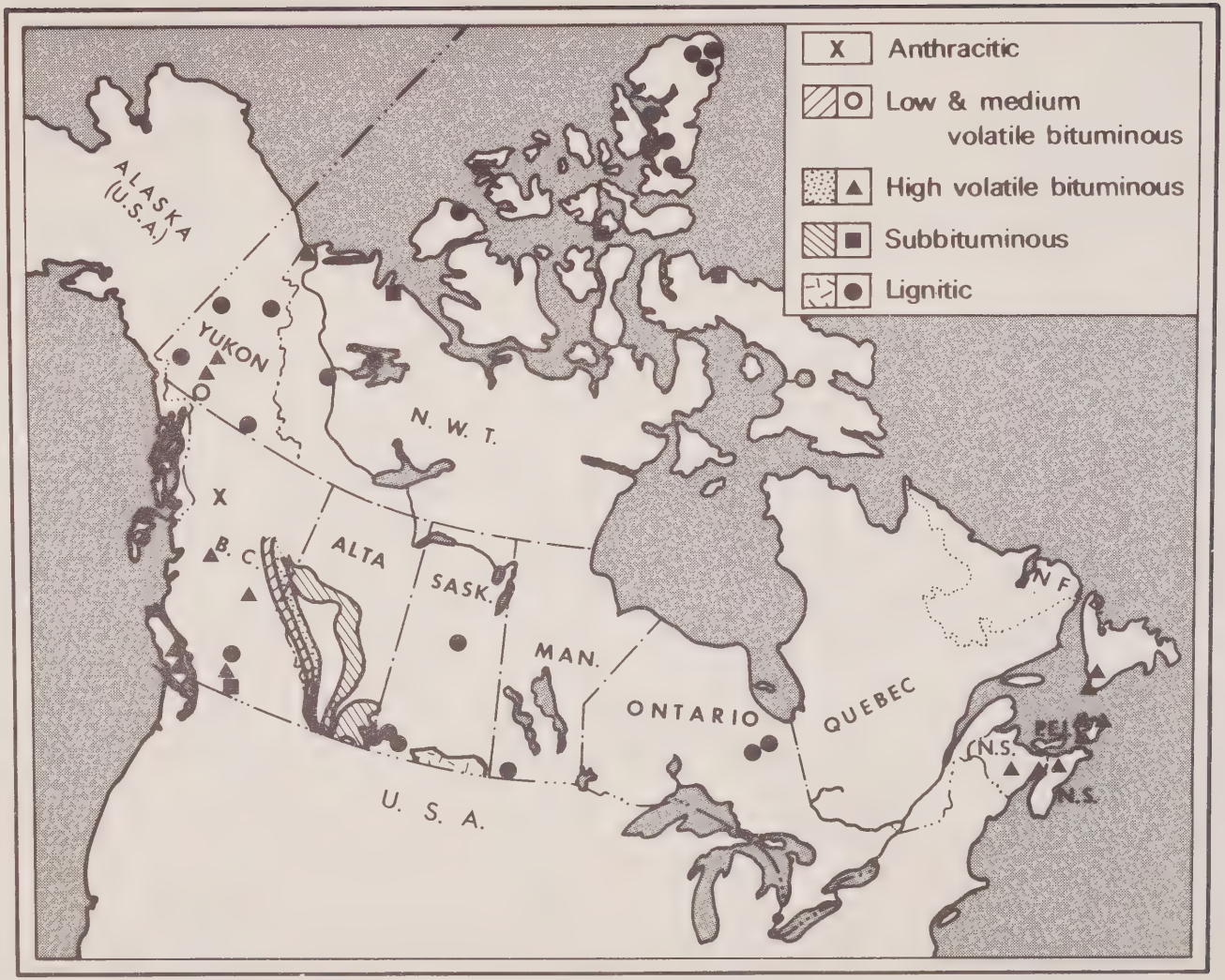


Figure 7. Coal deposits and occurrences (seams greater than 5 feet thick) by rank.

Assessment of Canadian coal reserves

Coal reserves refer to that portion of coal resources that has been reasonably well delineated and can be produced with current technology and delivered at competitive market prices. However, there are various ways of expressing this portion and unfortunately the term "reserves" is applied rather loosely to the various results (see below). Ideally, reserves should be calculated from data on geology and coal quality, and reported along with production costs. However, for this report, figures made available by operating companies and lease holders have been used to estimate reserves of recoverable coal; for these estimates costs are not available.

Reserve levels

The transformation of coal resources to reserves involves a series of economic and technological assessments. Each level, in this process, based on a better understanding of the coal deposit, reduces the available coal tonnage. The sequential process for any one area follows: (see Figure 8).

The geological and quality data base, used to determine measured and indicated resources is further qualified in terms of current technological limits and value of the final product. This general assessment will result in:

Reserve Level 1 — Mineable coal is an "in-place" tonnage which could represent less than 20 per cent of the initial resource. Specific feasibility studies are then carried out in terms of mining methods, extraction ratio, and cost.

That portion of the mineable coal which can be economically mined is called *Reserve Level 2 — Recoverable coal.* This is mined tonnage equivalent to "run-of'mine" or "raw" coal, which represents 40 per cent to 85 per cent of mineable coal (Level 1), depending on the mining method. Bituminous coal destined for the coking coal market may be upgraded in a cleaning plant to contract specifications. The output from such a plant is considered to be:

Reserve Level 3 — Clean coal This is a final-product tonnage, "free-on-rail", and represents 75 per cent to 50 per cent of recoverable coal (Level 2).

Mineable coal, Recoverable coal and *Clean coal* are different levels of reserves as long as two basic criteria are

TABLE IV

Quality of Canadian Raw Coals

Province and area	Rank (1)	Proximate Analysis—% (2) M	A	VM	FC	Sulphur %	Heating Value Btu / lb
Nova Scotia							
Sydney	hvAb	4.0	8.5	34.0	53.5	2.5	13,000
Other areas (3)	lvb to hvCb	3.9	22.0	27.0	47.5	2.9	10,800
New Brunswick							
Minto	hvAb	4.0	20.0	29.0	47.0	7.0	11,300
Beersville	hvAb	4.5	20.0	30.0	45.5	7.0	11,000
Ontario	lig	50.0	6.5	21.5	22.0	0.7	6,000
Saskatchewan (4)							
Estevan	lig	27.0	19.0	25.0	29.0	0.5	6,250
Willow Bunch	lig	25.0	22.0	24.0	29.0	0.5	6,100
Wood Mountain	lig	23.0	29.0	21.0	27.0	0.5	5,400
Cypress	lig	24.0	34.0	18.0	24.0	0.5	4,600
Alberta							
Plains Region	sub	20.5	7.5	30.0	42.0	0.4	8,850
Outer Foothills Belt	hvBb to hvCb	8.5	9.5	34.5	47.5	0.3	11,000
Inner Foothills Belt	lvb to hvAb	2.0	11.5	21.5	65.0	0.6	12,900
British Columbia							
Southeastern	mvb	2.0	15.0	18.5	64.5	0.5	12,900
Northeastern	lvb	2.0	4.5	20.0	73.5	0.5	14,600
South Central	sub to hvBb	18.0	8.5	31.0	42.5	0.6	9,700
Central	hvAb	4.0	11.0	25.0	60.0	1.0	12,700

(1) lig = lignitic sub = subbituminous hvAb = high volatile A bituminous hvBb = high volatile B bituminous hvCb = high volatile C bituminous lvb = low volatile bituminous mvb = medium volatile bituminous

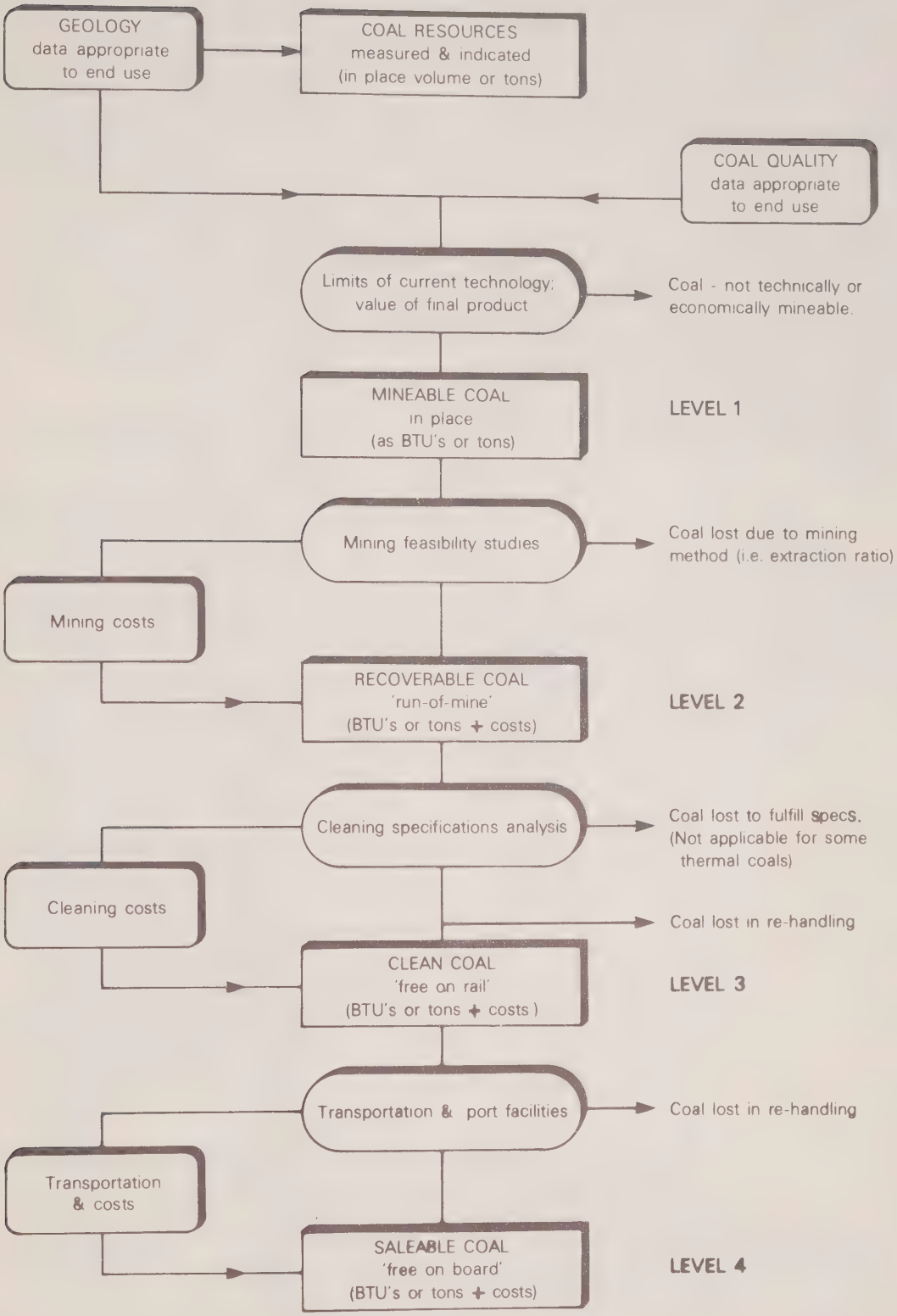
(2) Proximate analysis is the determination by prescribed methods of moisture (M), ash (A), volatile matter (VM) and fixed carbon by difference (FC).

(3) Averaged arithmetically.

(4) Analyses are from the first assessment of the Saskatchewan lignite resources from the current inventory program and are subject to revision in accordance with the ongoing program of certification of the coal chemistry file.

COAL RESOURCES TO RESERVES

WHAT NUMBERS DO WE USE ?



Note A : For some thermal coals SALEABLE COAL may be equivalent in tonnage and costs to CLEAN COAL, or even RECOVERABLE COAL.

Note B : Costs DO NOT include the INFRA STRUCTURE required to mine coal in remote locations.

Figure 8

met: 1) that infrastructure (transportation facilities, electric power, townsite, etc.) either exists or can be amortized from coal sales; and 2) that mining is permitted in the areas by government policy. If either criterion is not fulfilled, we have no reserves (e.g. there are no coal reserves in National Parks).

At this time the Department of Energy, Mines and Resources does not have the necessary data base to permit independent, accurate calculation of any of the levels of reserves portrayed in Figure 8. Assessment of the coal reserves at these various levels will be achieved through the National Coal Inventory Program.

Recoverable coal estimates

The reserves in Table V, reported in terms of Level 2 *Recoverable coal,* are based not on basic data but on interpretations of companies as reported on questionnaires which were mailed to coal leaseholders consisting of both operating and non-operating companies; moreover, not all companies responded. Recoverable coal held by some utilities for mine-mouth thermal plants is excluded. Because of this exclusion and the partial returns of the questionnaires, the estimate of recoverable coal presented in Table V is conservative.

TABLE V

Recoverable(1) Coal in Canada — 1976

(millions of short tons "raw coal")

Province and area	Recoverable coal	
	Coking(2)	Thermal(2)
Nova Scotia		
Sydney	54	37
Other	0	0
Sub total	54	37
New Brunswick		
Minto	0	19
Other	0	15
Sub total	0	34
Ontario	0	N/A
Saskatchewan	0	1,896
Alberta		
Plains	0	2,133
Outer Foothills	0	N/A
Inner Foothills	227	N/A
Sub total	227	2,133
British Columbia		
Southeastern	436	N/A
Northeastern	0	0
Other	N/A	1,114
Sub total	436	1,114
Canada total	717	5,214

(1) Recoverable coal refers to the part of a mineable coal deposit that can be delivered at the mine mouth as raw coal prior to further upgrading.

(2) Quality information is based on individual company intentions as to end use.

N/A Feasibility studies either not done or not available to EMR.

Recoverable coal of coking quality totalling 0.7 billion tons is situated in Nova Scotia, Alberta and British Columbia. Recoverable coal for thermal use which totals 5.2 billion tons is located in all five producing provinces.

It should be noted that a significant tonnage of coal could not be reported in Table V, because the basic conditions of the presence of infrastructure and permission to mine were not met. Included in this category were 0.89 billion tons of coking coal in northeastern British Columbia and the Inner Foothills of Alberta, and 0.87 billion tons of thermal coal mostly in the Plains region of Alberta.

Cost evaluation of reserves

The technical feasibility of mining and upgrading a particular coal deposit is only a part of reserve assessment. It is even more important to be able to produce the coal at an acceptable cost. Figure 8 shows that costs should be reported along with tonnages beyond Level 1. At this time it is not possible to report costs at any level within the reserve classification.

Current coal mining methods in Canada

Coal mining methods in Canada are dependent upon the type of coal mined and the conditions under which it occurs. The rank of the coal, to some degree, limits the end use of the product mined and also the market value. The lignites and subbituminous coals are used for mine-mouth thermal power generation and have a market value of less than $5 per short ton for coal at the mine site. On the other hand, some of the low to medium volatile bituminous coals used for coke production have a market value of over $50 per short ton for clean coal at the mine site. This price differential has a direct bearing on allowable mining expenditures and, therefore, places a limit on the mining methods that may be used.

Basically, there are two classes of mining methods: surface mining — where the material overlying the coal seam is removed in order to gain access to the coal; and underground mining — where the coal itself is mined between the overlying and underlying strata. Surface mining accounted for 86 per cent of the saleable coal tonnage mined in 1976; the remainder being mined by underground methods.

Active mining areas and the ranks of coal mined there, are shown on Figure 9. Details on each mine can be found in "Operators List 4, Coal Mines in Canada, 1977, EMR".

Surface mining is capital-intensive and has generally a high output per man day. Two different methods are commonly used:

1. Dragline stripping — where the overburden is removed by a dragline and cast back into the mined out area. In this way a furrow is opened up exposing the coal which can then be removed by truck and shovel. When the coal has been recovered, the strip is back-filled with the overburden from the next furrow. This method is commonly called "strip mining".
2. Truck-and-shovel stripping — where the overburden is transferred by trucks from the pit to specified waste dumps outside the working pit. In this method material handling costs are higher than in "strip mining".

The two methods may be combined where multiple seams are mined. A number of small operators utilize front-end loaders, scrapers and other equipment instead of shovels or draglines.

Underground mining, by comparison with surface mining, is labour-intensive, and, therefore usually results in lower output per man per shift. Access to the coal is

Figure 9. Operating coal mines — 1976.

achieved by slopes, tunnels or shafts, which are used for transportation and haulage, and for airways. Two basic types of underground mining are currently used in Canada:

1. Longwall mining — where coal is cut by a shearing machine operating along a coal face approximately 400 feet in length. The coal is removed from the face by an armoured-chain conveyor. Development tunnels for longwall faces are driven in the coal while the face is advancing. The length of each panel mined by this method is typically 2,000 to 3,000 feet. The overlying strata are allowed to cave behind the powered supports. The development tunnels are usually cut with a continuous miner.

2. Room-and-pillar mining — where a network of tunnels in the coal seam, known as entries and crosscuts, are mined to leave a checkerboard pattern of pillars which may be extracted eventually or left for roof support purposes. Entries and crosscuts are usually cut with a continuous miner and shuttle cars are used to transport the coal to conveyors. In one mine, tunnels are advanced by blasting and coal is moved from the face with slushers. Pillar extraction is currently being carried out by both of the above methods. One operation uses hydraulic monitors to cut the coal during pillar extraction. Within this mine, coal transportation is solely by water in open flumes.

The amount and value of coal produced in 1976 is classified in Table VI by mining method. Totals for various areas and mining methods are shown. The figures show that, while thermal coal accounts for 53 per cent of the tonnage produced, it represents only 15 per cent of total value.

TABLE VI

1976 Coal Production by Mining Methods
(Amount[1] and value[2] reported by area, mining method and rank[3])

Mining methods		Rank[3]	Maritimes		Saskatchewan		Alberta Plains		B.C. and Alta. foothills and mountains		Total by mining method	
			000 short tons (000 $)	% of Total	000 short tons (000 $)	% of Total	000 short tons (000 $)	% of Total	000 short tons (000 $)	% of Total	000 short tons (000 $)	% of Total
Open pit	Dragline stripping	Thermal lig.			5,156 (12,993)	18 (2)						
		Thermal sub. b.					6,551 (18,801)	23 (3)			13,839 (109,833)	49 (18)
		Thermal bit.	327 (6,435)	1 (1)								
		Coking bit.							1,805 (71,604)	7 (12)		
	Truck and shovel stripping	Thermal sub.b.					471 (1,349)	2 —				
		Thermal bit.							889 (15,369)	3 (2)	10,272 (382,653)	37 (62)
		Coking bit.							8,912 (365,935)	32 (58)		
Underground	Longwall	Thermal bit.	1,673 (32,690)	6 (5)								
		Coking bit.	400 (17,264)	2 (3)							2,073 (49,954)	8 (8)
	Room and pillar	Thermal sub.b.					44 (126)	— —				
		Thermal bit.	132 (2,579)	— —							1,899 (74,001)	6 (12)
		Coking bit.							1,723 [4] (71,306)	6 (12)		
Total by area			2,532 (58,968)	9 (9)	5,156 (12,993)	18 (2)	7,066 (20,276)	25 (3)	13,329 (524,214)	48 (84)	28,083 (616,451)	100 (100)

1) Amount — in thousands of short tons, saleable coal.
2) Value — in thousands of dollars, f.o.b. mine site.
3) Thermal vs. coking coal based on producer's marketing decision.
4) Includes coal mined hydraulically.

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Appendix

Resource terminology

A meaningful appraisal of Canadian coal resources can only be made in the context of a classification scheme that takes into account the wide diversity inherent in the coal deposits. The coal resource classification scheme used in this report (Figure 2) has some similarities to the schemes used for petroleum and mineral resources but it does differ, as it must, in order to accommodate the modes of occurrence that are unique to coal. The scheme classifies coal resources according to two basic considerations: (1) the assurance of existence (accuracy of measurement); and (2) the feasibility of exploitation. The definitions of terms used in this scheme, and as presented below, are similar to those used in the United States (Averitt, 1969) but are modified to suit the highly variable conditions under which coal occurs in Canada.

Resources

The term *coal resources* refers to concentrations of coal of certain characteristics and occurring in the ground within specified limits of seam thickness and depth from surface.

A. Level of assurance of existence

The terms "measured", "indicated", "inferred" and "speculative" denote the precision with which given quantities of resources have been determined or estimated; they are defined as follows:

Measured resources are resources for which tonnages are computed from dimensions revealed in outcrops, trenches, mine workings and boreholes. The spacing of points of observation necessary to justify confidence in the continuity of coal seams differs from region to region according to the character of the seams. In general, the points of observation should be separated by less than the following distances:

Cordillera: 1,000 feet (500 feet in severely contorted areas)
Plains: 1/2 mile
Maritimes: 1,000 feet

Indicated resources are resources for which tonnages are computed partly from specific measurements and partly from reasonable geological projections. In general the points of observation should be separated by less than the following distances:

Cordillera: 2,000 feet (1,000 feet in severely contorted areas)
Plains: 1 mile
Maritimes: 2,000 feet

Inferred resources are resources for which quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region and for which few measurements of seam thickness are available. The estimates are based primarily on an assumed continuity of coal seams in areas remote from the points of observation used to calculate measured or indicated resources.

Speculative resources are resources for which quantity estimates are based on information from a few scattered occurrences. Resources of this description are mainly in frontier areas where coal mining or exploration have not taken place.

B. Feasibility of exploitation

Resources of immediate interest consist of coal seams that, because of favourable combinations of thickness, quality, depth, and location, are considered to be of immediate interest for exploration or exploitation activities. The conditions set out below do not apply rigorously in each case, but they give a general indication of thickness and depth of coal seams included in this category. In all areas, coal beds are included that are thinner or deeper than listed below but are nonetheless being mined at this time.

Cordillera: Coal of all ranks in beds at least 5 feet thick that can be surface-mined.
Anthracitic and bituminous coal seams at least 5 feet thick, at depths to 1,000 feet, that are too deep for surface mining but might be mined underground.
Plains: Bituminous and subbituminous coal beds at least 5 feet thick, at depths to 750 feet. Lignite seams at least 5 feet thick that can be surface mined (generally at depths less than 150 feet).
Maritimes: For land areas, coal seams at least 3 feet thick at depths to 1,000 feet. For submarine areas, coal seams at least 5 feet thick within 5 miles from shore and with not more than 4,000 feet of vertical cover.

Resources of future interest are coal seams that, because of less favourable combinations of thickness, quality, depth, and location, are not of immediate interest but may become of interest in the foreseeable future. The following limits are applied (excluding the resources of immediate interest described above):

Cordillera: Seams at least 5 feet thick to a depth of 2,500 feet.
Plains: Seams at least 3 feet thick to a depth of 1,500 feet.
Maritimes: For land areas, coal seams at least 3 feet thick to a depth of 4,500 feet. For submarine areas, coal beds at least 5 feet thick that are either beyond 5 miles from shore or have more than 4,000 feet of vertical cover, or both.